CubeRRT: CubeSat Radiometer Radio Frequency Interference Technology Validation

Completed Technology Project (2015 - 2018)

Project Introduction

We propose the CubeSat Radiometer Radio Frequency Interference (RFI) Technology Validation (CubeRRT) mission to demonstrate wideband RFI mitigating backend technologies vital for future space-borne microwave radiometers. Recent passive microwave measurements below 40 GHz have shown an increase in the amount of man-made interference, corrupting geophysical retrievals in a variety of crucial science products, including soil moisture, atmospheric water vapor, sea surface temperature, sea surface winds, and many others. Spectrum for commercial use is becoming increasingly crowded, accelerating demand to open the bands reserved for passive microwave Earth observation and radio astronomy applications to general use. Due to current shared spectrum allocations, microwave radiometers must co-exist with terrestrial RFI sources. For example, the GPM Microwave Imager currently in orbit is impacted by RFI from commercial systems over both land and sea. As these sources expand over larger areas and occupy additional spectrum, it will be increasingly difficult to perform radiometry without an RFI mitigation capability. Co-existence in some cases should be possible provided that a subsystem for mitigation of RFI is included in future systems. Successful RFI mitigation will not only open the possibility of microwave radiometry in any RFI intensive environment, but will also allow future systems to operate over a larger bandwidth resulting in lower measurement noise. This crucial technology is required for the US to maintain a national capability for spaceborne microwave radiometry. Initial progress in RFI mitigation technologies for microwave radiometry has been achieved in the SMAP mission, which is currently operating in space a digital subsystem for this purpose in a 24 MHz bandwidth centered in the protected 1413 MHz band. RFI subsystems for higher frequency microwave radiometry over the range 6-40 GHz however require a larger bandwidth, so that the capabilities of RFI mitigation backends in terms of bandwidth and processing power must also increase. To date, no such wideband subsystem has been demonstrated in space for radiometers operating above 1413 MHz. The enabling technology is a digital Field-Programmable Gate Array-based spectrometer with a bandwidth of 1 GHz or more and capable of implementing advanced RFI mitigation algorithms such as the kurtosis and cross-frequency methods. This technology has a strong ESTO heritage, with the algorithms developed and demonstrated via the Instrument Incubator Program (IIP) and wideband backends developed under other ESTO support. The digital backend is currently at TRL 5, having been successfully tested in an RFI environment, and can be ported easily to a flight-ready firmware. Though the technology can be demonstrated for any frequency band from 1 to 40GHz, we will integrate the backend with a wideband radiometer operating over a 1 GHz bandwidth tunable from 6-40 GHz to demonstrate RFI detection and mitigation in important microwave radiometry bands. Along with a wideband dual-helical antenna, the payload will be integrated with a 6U CubeSat to demonstrate operation of the backend at TRL 7. The payload is expected to operate at a minimum duty-cycle of 25% to be compatible with spacecraft power capacity.

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Organizational Responsibility

Responsible Mission Directorate:

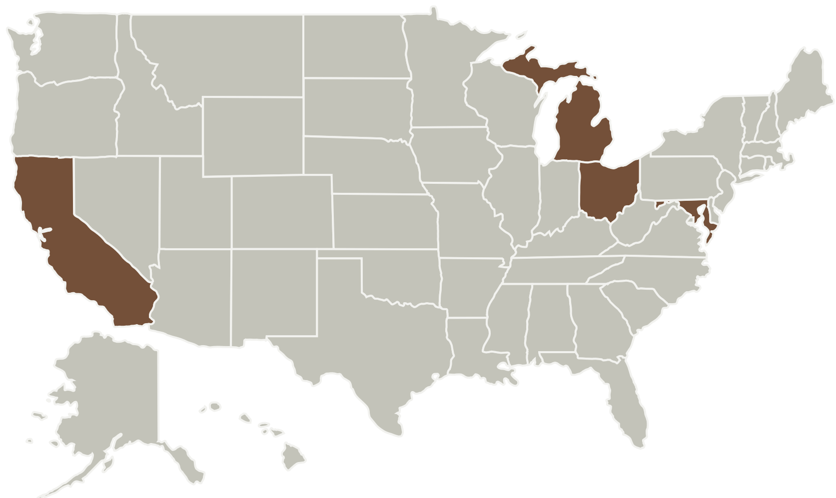
Science Mission Directorate (SMD)

Responsible Program:

In-space Validation of Earth Science Technologies

Although the spatial resolution to be achieved will be coarse (due to the limited antenna size possible), the goal of demonstrating observation, detection, and mitigation of RFI is achievable in this configuration. The proposed demonstration will act as an immediate risk reduction of new technologies that are necessary for future Earth science missions. The technology will allow newly enabled measurements by operating in previously untenable spectral regions over larger bandwidths. The benefits from the above technology are directly relevant to all future microwave Earth science missions, such as SCLP, GMI follow on, SMAP follow on, and others.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ohio State University-Main Campus	Supporting Organization	Academia	Columbus, Ohio

Primary U.S. Work Locations	
California	Maryland
Michigan	Ohio

Project Management

Program Director:

Pamela S Millar

Program Manager:

Sachi Babu

Principal Investigator:

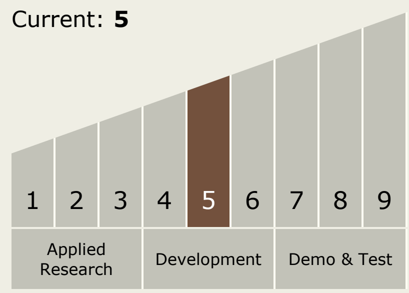
Joel T Johnson

Co-Investigators:

Jared F Lucey
Jonathon Kocz
Chi-chih Chen
Damon C Bradley
Christopher S Ruf
Jeffrey R Piepmeier
Sidharth Misra
James F Ball
Shannon T Brown
Priscilla N Mohammed-tano
Robert F Jarnot

Technology Maturity (TRL)

Start: **5**
Current: **5**



Technology Areas

Primary:

Continued on following page.

Technology Areas *(cont.)*

- TX08 Sensors and Instruments
  - └─ TX08.1 Remote Sensing Instruments/Sensors
    - └─ TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

Earth